REMARKS

This application has been reviewed in light of the Office Action dated November 2, 2005. Claims 1-12 are pending in this application, of which Claim 1 is in independent form.· Dependent claims 11 and 12 have been amended.

Claims 1-10 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No.6,168,965 B1 (*Malinovich*) in view of U.S. Patent No. 4,577,345 (*Abramov*).

Claims 11 and 12 were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Malinovich* in view of *Abramov*, and further in view of U.S. Patent No. 6,724,855 B2 (*Suguwara et al.*).

Applicant has carefully studied the prior art and the Office Action, but is unable to agree with the rejection, for at least the following reasons.

Applicant points to Claim 1, which is directed to a back side incident type image pickup sensor. The front side of a semiconductor substrate of the image pickup sensor has is a photoelectric conversion portion and an electric circuit. The back side of the semiconductor substrate of the image pickup sensor has an opening through which a radiation beam is incident. The incident radiation beam is detected by the photoelectric conversion portion formed on the front side of the semiconductor substrate. The electric circuit is disposed at a given distance in the horizontal direction from the opening. By virtue of the recited structure, the present invention provides an image sensor structure which can be optimally configured quantitatively without increasing its substrate size.

These features may be understood by referring, for example, to the specification at pages 6 and 7, which is an example of a design configuration in accordance with the claimed invention. A configuration in accordance with the claimed invention yields the following results:

$$\sin\theta 2 = \sin\theta 1/(3.448),$$

where $\theta 1$ is an arbitrary angle and 3.448 is the approximate refractive index of a single crystal silicon substrate for a wavelength in the visible light range. $\sin\theta 2$ thus is .290 at a maximum, and the angle $\theta 2$ is calculated as follows:

$$\theta 2 = \sin\text{-}1\ (0.290) = 16.859^\circ$$

This angle $\theta 2$ defines a cone that contains the light flux incident in a single crystal silicon substrate. In other words, the light that enters silicon is completely contained in a cone with an apex angle of $\pm$ 16.859°. Since the refractive index of the single crystal silicon is larger than, for example, 3.448, the incident light flux is not diffused much within the substrate. Thus, even if the thickness of the substrate is relatively large, the "given distance" referred to above for light shielding can be made smaller than the thickness of the substrate. Thus, among the advantages of having an electric circuit "disposed at a given distance in the horizontal direction from the opening" is that image sensor structure can be optimally configured by varying the thickness of the substrate. In front side incident type image pickup sensors a variation in thickness of a semiconductor substrate has no such meaningful effect.

Malinovich et al., as understood by the Applicant, relates to a method for producing backside illuminated image sensors. Apparently, *Malinovich et al.*, as described at col. 6, lns. 5-23, with reference to Fig. 3(B), uses a wafer 300 with image sensor circuits 100. The wafer 300 includes a first (frontside) surface 310 and a second (backside) surface 320. Each image sensor circuit 100 is formed on first surface 310, and includes a matrix of light sensitive pixel regions 110 extending into wafer 300 from first surface 310. Each image sensor circuit 100 also includes control circuitry 120 (see Fig. 1) extending into wafer 300 from its surface. Each image sensor circuit 100 also includes control circuitry 120 and a plurality of metal contact pads 330 extending into wafer 300 from first surface 310. The wafer 300 has a beginning thickness of 600 to 650 μm. Nothing has been found

in *Malinovich et al.* that would teach or suggest "an opening through which a radiation beam is incident, the incident radiation beam being detected by the photoelectric conversion portion formed on the front side of the semiconductor substrate" or "[an] electric circuit [that] is disposed at a given distance in the horizontal direction from the opening", as recited in Claim 1.

Abramov, as understood by the Applicant, is directed to an electrical method and apparatus for sensing the pattern of ridges and valleys on an individual's finger to provide binary electrical signals representative of the sensed pattern. As explained at col. 5, line 19, *et seq.*, a sensor S is formed of a silicon substrate. A specific array of switching circuits that may be deposited on the semiconductor chip, which is illustrated in FIG. 5.

Nothing in *Abramov* has been found that would teach or suggest "[an] electric circuit [that] is disposed at a given distance in the horizontal direction from the opening", as recited in Claim 1. Applicant further submits that one skilled in the art could not combine the *Malinovich et al.* and *Abramov* sensors as the Examiner suggests, to "increase the longevity of the circuit components by reducing its exposure to radiation" by simply making larger "a given distance", without undesirably enlarging the image sensor area and the chip area and increasing cost. Moreover, even if one of merely ordinary skill would consider combining them, the result would not have "[an] electric circuit [that] is disposed at a given distance in the horizontal direction from the opening", as recited in Claim 1.

Accordingly, Applicant respectfully submits that Claim 1 is in condition for allowance.

The other claims in this application are each dependent from Claim 1 discussed above and are, therefore, believed patentable for the same reasons.

Claims 11 and 12, for example, have been amended to recite a dummy pixel (Claim 11) and diffusion region (Claim 12) formed in an offset portion between the electric

circuit on the front side of the semiconductor substrate and the opening configured to remove an electric charge in the offset portion. Initially, Applicant notes that the design policy for implementing a dummy pixel and/or a diffusion region into a back side light incident type sensor, as recited in the claims of the present invention, is different than the design policy required to implement a dummy pixel and/or a diffusion region in a front side light incident type sensor as disclosed in *Sugawara* and *Abramov*.

Sugawara, as understood by the Applicant, is directed to an X-ray flat panel detector including "effective" and "dummy" pixels that are arranged adjacent to the effective pixel area and which generate electrical signals irrelevant to X-rays. Apparently, as shown in Fig. 2 of *Sugawara*, pixel areas formed by respective pixels when the X-ray sensor elements 16 are classified into effective pixels, dummy pixels A (DA), and dummy pixels B (DB). Pixels which constitute each pixel area are formed from the sensor elements 16. DAs are arranged above and below the effective pixel area in the column direction (direction parallel to the signal line) and DBs are pixels arranged on the right and left sides of the effective pixel area in the row direction (direction parallel to the scanning line), as shown in Fig. 2. Nothing has been found in *Sugawara* that would teach or suggest "an opening through which a radiation beam is incident, the incident radiation beam being detected by the photoelectric conversion portion formed on the front side of the semiconductor substrate" or "[an] electric circuit [that] is disposed at a given distance in the horizontal direction from the opening", as recited in Claim 1.

Applicant further submits that *Abramov* and *Sugawara* relate to "front side" sensors – not to "a back side incident type image pickup sensor", as recited in Claim 1. In front side incident type image pickup sensors, a variation in thickness of the semiconductor substrate provides an optimized configuration of the image sensor structure by having an electric circuit that is disposed at "a given distance" in the horizontal direction from the opening. Such a feature advantageously results in improved resolution. In contrast, Claim

1 recites that "the electric circuit is disposed <u>at a given distance in the horizontal direction</u> from the opening", which provides a significantly optimized configuration based on the substrate thickness.

In the case of the back side light incident type sensor, the dummy pixel and the diffusion region provide larger contributions with respect to suppressing the degradation of a sensor's performance due the photo carrier generated in the area between the electric circuit and the opening. Accordingly, the claimed back side incident type sensor provides a technical advantage over the front side light incident type sensors disclosed in *Sugawara* and *Abramov*

Since each dependent claim is also deemed to define an additional aspect of the invention, the individual reconsideration of the patentability of each on its own merits is respectfully requested.

In view of the foregoing amendments and remarks, Applicant respectfully requests early and favorable continued examination of the present application.

Applicant's undersigned attorney may be reached in our New York office by telephone at (212) 218-2100. All correspondence should continue to be directed to our address given below.

Respectfully submitted,

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